Abstract

Static balance is the reduction or elimination of the actuating effort in quasi-static motion of a mechanical system by adding non-dissipative force interactions to the system. In recent years, there is increasing recognition that static balancing of elastic forces in compliant mechanisms leads to increased efficiency as well as good force feedback characteristics. The development of insightful and pragmatic design methods for statically balanced compliant mechanisms is the motivation for this work. In our approach, we focus on a class of compliant mechanisms that can be approximated as spring-loaded rigid-link mechanisms. Instead of developing static balancing techniques directly for the compliant mechanisms, we seek analytical balancing techniques for the simplified spring–loaded rigid–link approximations. Towards that, we first provide new static balancing techniques for a spring-loaded four-bar linkage. We also find relations between static balancing parameters of the cognates of a four-bar linkage. Later, we develop a new perfect static balancing method for a general n-degree-of-freedom revolute and spherical jointed rigid-body linkages. This general method distinguishes itself from the known techniques in the following respects:

1. It adds only springs and not any auxiliary bodies.
2. It is applicable to linkages having any number of links connected in any manner.
3. It is applicable to both constant (i.e., gravity type) and linear spring loads.
4. It works both in planar and spatial cases.

This analytical method is applied on the approximated compliant mechanisms as well. Expectedly, the compliant mechanisms would only be approximately balanced.

We study the effectiveness of this approximate balance through simulations and a prototype. The analytical static balancing technique for rigid-body linkages and the study of its application to approximated compliant mechanisms are among the main contributions of this thesis.